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AUTHOR Schlenker, Richard M.
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ABSTRACT

This paper discusses several inexpensive methods of evaluating the salinity of seawater. One method is presented in some detail. This method has several attractive features. First, it can be used to provide instruction, not only in marine chemistry, but also in studying the mathematics of the point slope formula, and as an aid in teaching students to control variables. In addition, it can be used in the study of electrical resistance. Information about how to build the featured equipment and parts list are also included. The other seven methods of evaluating salt water include comparisons of masses of solutions, a stream of water and a charged rod, boiling point elevation, freezing point lowering, and buoyancy studies. Illustrations are found throughout the paper and a listing of references concludes the paper. (Author/MA)

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HOME BREW SALINITY MEASURING DEVICES: THEIR CONSTRUCTION AND USE

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Richard M. Schlenker
Department of Arts and Sciences
Maine Maritime Academy
Castine, Maine
September 1977

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ABSTRACT

The paper discusses several inexpensive methods of evaluating the salinity of seawater. One method is presented in some detail. This method has several attractive features. First, it can be used to provide instruction, not only in marine chemistry, but also in studying the mathematics of the point slope formula, and as an aid in teaching students to control variables. In addition, it can be used in the study of electrical resistance. Information about how to build the feature equipment, as well as a parts list are also included.

INTRODUCTION

Commercial salinity measuring instruments are, for the most part, so expensive that it is not economically feasible to use them in all but the most advanced laboratory situations. In most cases, students must wait until they enter college in order to gain experience with this type of equipment and the concepts it involves, however, this need not be the case. It is possible for the average teacher to build several different styles of such an instrument. Several of the devices are presented in the following context, and one is discussed extensively.

The feature salinity measuring instrument discussed herein has several attractive features. First, it can be built at a minimum cost and construction does not require extensive technical abilities. In addition, the instrument can be used not only to show students how to measure the salinity of a seawater sample but also as a device to measure salinity. Finally, the instrument may be used in the study of electrical resistance, and the mathematical aspects of Cartesian Coordinates and the point slope formula.

Like all scientific measurements, that of salinity, in order to be reasonably accurate must take into account the various confounding parameters, for example, that of temperature. In order to obtain the best results when measuring the salinities of a series of samples, all measurements should be made at the same temperature. Since the meter is essentially a teaching

tool, it matters not what temperature is chosen so long as that temperature is maintained throughout a series of measurements. Further, the volume should be controlled, that is to say, the same volume of water should be used each time a measuement is made. It naturally follows that any controls which will result in more accurate use of the meter should be used without hesitation.

MATERIALS

The following list of materials are necessary for the building and use of one salinity measuring instrument.

1. One 250ml beaker.
2. One 6V or 1½V battery. The voltage rating of the battery to be used will control the magnitude of full scale deflection which must be covered by the meter used in the circuit.
3. One spring loaded toggle switch (loaded such that constant pressure must be applied in order to hold the switch in the on postion).
4. Four wire leads with alligator clips on both ends.
5. Two strips of thin copper plates 2.2cm x 13.2cm.
6. Two rubber bands.
7. One piece of wood 2.2cm x 2.2cm x 13.2cm.
8. One small piece of steelwool.
9. A quantity of table salt.
10. A balance or scale for weighing quantities of salt.
11. Several 100ml or other conveniently sized collecting bottles.

12. A bottle which holds at least one liter.

13. A sturring paddle.

14. A 100ml graduated cylinder.

15. A watch with a second hand.

16. Recording paper.

17. One DC milliammeter (the full scale reading will be determined by the size of the battery to be used, or the converse).

18. A thermometer marked in ^{o}C.

19. Several sample collecting bottles.

DISCUSSION

Construction details and those necessary for proper use of the salinity meter are included in this section. Figure 1 shows the equipment as it physically should appear when it is set up.

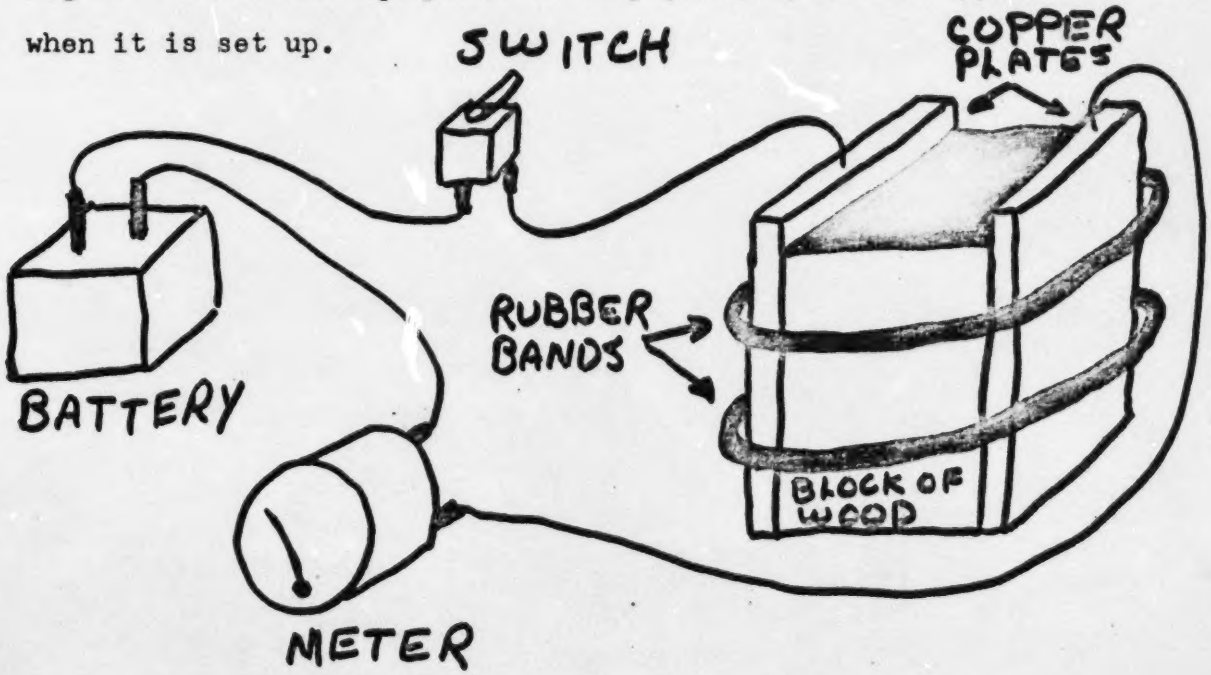


Figure 1, The Physical Arrangement of the Salinity Meter When it is Ready for Use

Calibrtion of the Meter. The first priorty in using the meter is understanding some basic facts concerning salt water. The salinity of the standard ocean is 35 parts per 1000 parts of seawater (35 o/oo). This means that 35 parts of every 1000 parts of seawater is salt. Translated into grams, for every 1000 grams of seawater 35 grams consist of salt. It follows then that 100 grams of salt would be included in 1000 grams of seawater whose salinity were 100 o/oo.

The next step is to make some test solutions. In order to make a solution of 35 o/oo you need weigh 35 grams of salt and 965 grams of water (distilled water is preferred but not necessary). The salt is then dissolved in the water and the solution sturred throughly with the sturring paddle. Solutions of varying salinities may be made by varying the relative proportions of salt and water.

The testing phase requires control and precaution. Approximately 100ml of solution should be poured into the 250ml beaker (100ml need not be the volume used but the same volume should be used each time the salinity of a different sample in a series is measured). The probe is then inserted in the solution in a verticle position such that it touches the bottom of the beaker (this procedure is followed each time a new measurement is made). Once the probe has been inserted in the solution, the spring loaded switch is pressed to the on position and held on long enough to take a meter reading, say five seconds (with each measurement in a series, the switch should be held in the on position for

the same amount of time).

Electrolysis and buildup occur rapidly. The moment the switch is placed in the on position, an electric current flows between the two plates. As soon as the current begins to flow, a buildup starts on the copper plates. The buildup (a discussion of the buildup is beyond the scope of this paper) decreases the amount of current which can pass between the plates, and so the magnitude of the meter reading decreases as a function of time. A maximum amount of control is exercised over this phenomenon if, as previously mentioned, the amount of time is controlled during which current flows between the two plates, and if the copper plates are cleaned with a piece of steelwool after each reading.

The reading obtained from each test solution should be recorded. Since the salinities of the test solutions are known, the combination of known salinities and accumulated readings will form the basis of a meter calibration chart. Figure 2 shows such a calibration chart.

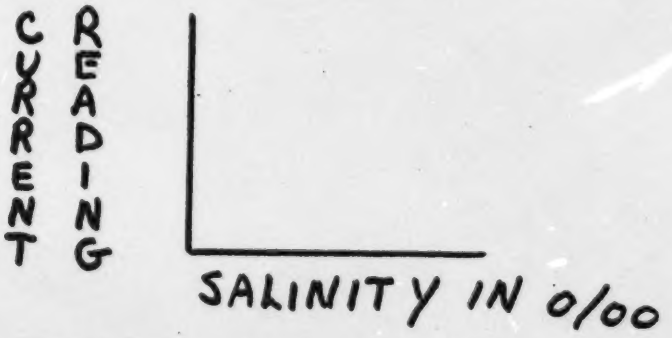


Figure 2, Salinity vs Current Flow at____Degrees C

One additional control may be added to the system. Each reading should be made at the same temperature. While this practice may be time consuming and require forethought on the part of the teacher, it does allow a more throughly controlled system.

Introducing the salinity meter in this manner forces the student to deal with variables and their control. The objective, of course, is to show the student that in order to achieve the best results, all variables but one should be held constant. In the end, the student should have not only a better feel for the measurement of salinity and the control of variables, but a better feeling for the investigative process in general.

Use of the Salinity Measuring Instrument in the Environment. Use of the instrument requires water sample of unknown salinity. If the temperature, emersion time of the probe, and other parameters discussed in the test phase (above) are controlled as previously discussed, then it is possible to use the salinity chart shown in Figure 2. In order to use the chart one need only to take a current reading. The current reading is then located on the Y axis of the current chart and a line horizontal to the X axis is drawn to the best fit line (the line which best fits the data obtained in the derivation of Figure 2). In order to find the salinity of the sample, a perpendicular is dropped from the point of intersection

of the best fit line (by the line from the Y axis)to the X axis. The value at the point where the perpendicular intersects the X axis is the salinity of the sample. Figure 3 shows this procedure.

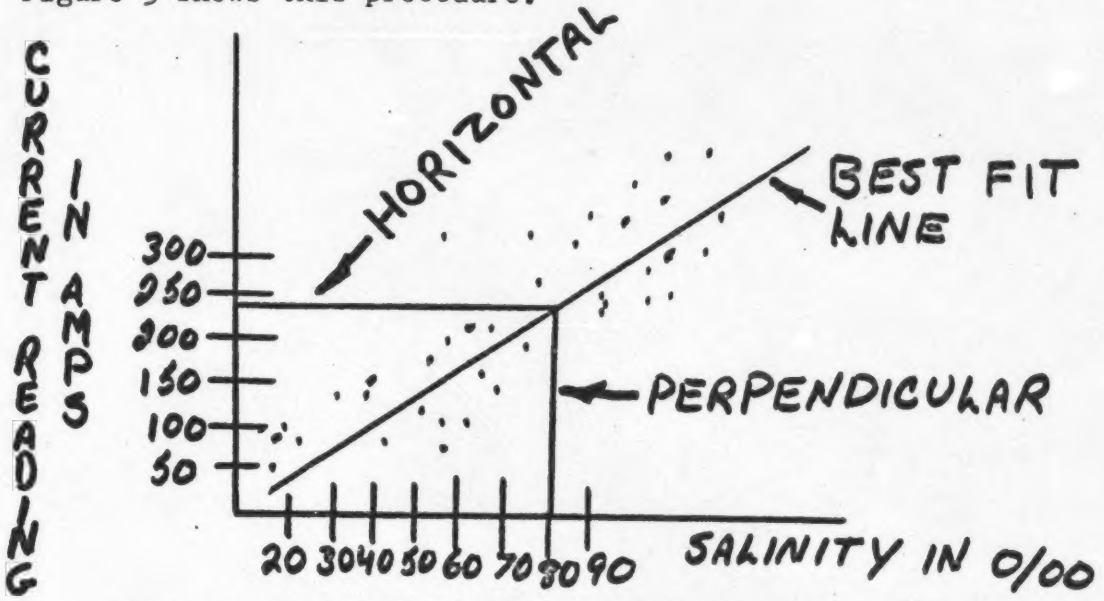


Figure 3, A Method of Finding Salinity From a Given Current Reading

USING THE SALINITY METER TO TEACH ELECTRICITY

The salinity meter can most easily be used in developing the concept of resistance. The meter, as it is shown physically in Figure 1, is shown electrically in Figure 4.

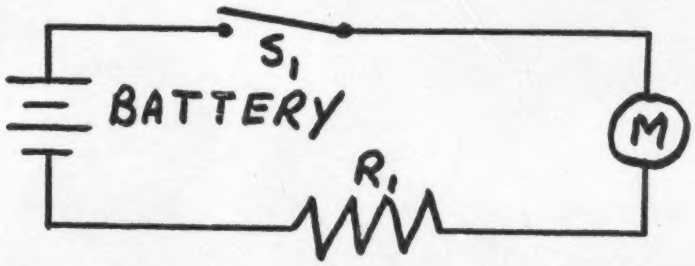


Figure 4, The Salinity Meter Shown Electrically

Resistor, R1, represents that part of the meter labeled probe in Figure 1. The resistance varies as the salinity of the water between the plates of the probe varies. Ohm's law should make the situation more comprehensible. You will recall that according to Ohm, current flow is directly proportional to the magnitude of the voltage present and inversely proportional to the magnitude of the resistance.

$$I = E/R$$

In terms of salinity, for our purposes, the resistance in in the circuit is inversely proportional to the salinity of the water between the plates. This means that the greater the salinity (in parts per thousand) the lower will be the resistance between the plates. Since the sum of the voltage drops around a series circuit are equivalent to source voltage, and current flow in a series circuit is common, the magnitude of current flow in the circuit for a given voltage is a function of salinity. For example, if the battery is rated at 6VDC and the resistances between the plates of the meter are those shown in column 2 below, then the current flow for each of three different salinity measurements is that shown in column 3.

Salinity Measurements	Voltage	Resistance	Current Flow
1	6VDC	10 Ohms	0.6A
2	6VDC	20 Ohms	0.3A
3	6VDC	30 Ohms	0.1A

Another approach, although not as sophisticated as using a meter in the circuit as shown in Figure 4, is to replace the meter with a lamp. This change is shown in Figure 5.

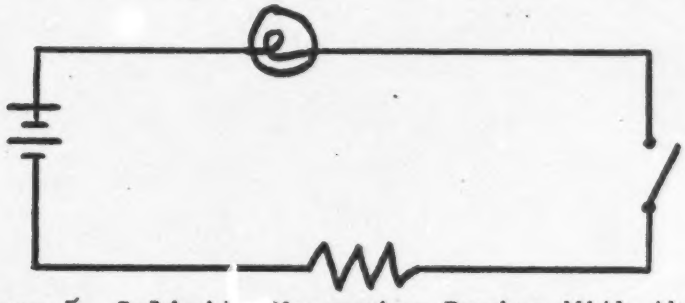


Figure 5, Salinity Measuring Device With the Meter Replaced by a Lamp

The student who uses this configuration will see a change in the brilliance of the lamp as the probe is inserted in samples of different salinities (this might be a good approach if one wants to have students discover the effect on current flow of changing salinity).

USING THE SALINITY METER TO TEACH CARTESIAN COORDINATES AND THE POINT SLOPE FORMULA

Teaching the point slope formula can be accomplished as the students collect test data from their samples of unknown salinities. Since the resistance between the plates is dependent upon the salinity of the solution, the current flow between the plates is also dependent upon the salinity. Current flow in milliamps is plotted on the y axis of a Cartesian Coordinate system. It follows that the salinity in parts per thousand is plotted on the x axis. Once

several seperate salinity vs current flow readings have been collected, they are plotted on the coordinate system, see Figure 6.

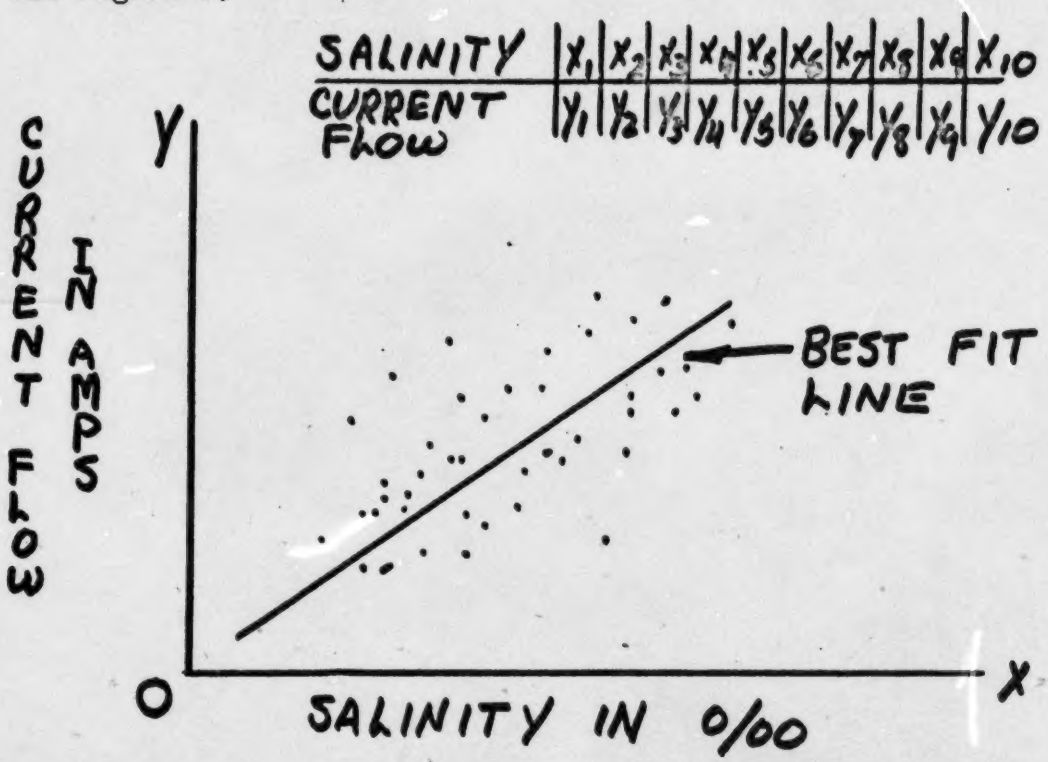


Figure 6, Graph Showing Plots and the Best Fit Line

Then a line is plotted which best fits the data. Once the line has been plotted, it is necessary to ascertain the equation for the line. In its generalized form, the formula for any best fit line is;

$$y = mx + b$$

M is the slope of the line while b is the y intercept, or that point where the best fit line intercepts the y axis. First, let

us determine the value of the slope, where the slope is defined as the rise divided by the run.

$$m = \text{slope} = \text{rise/run}$$

In order to determine the slope, it is first necessary to locate two points on the best fit line. Then two lines are drawn through each point. One line through each point is parallel to the y axis, while the second line through each point is drawn parallel to the x axis. All lines are drawn such that they intersect either the x or the y axis. This procedure is shown in Figure 7.

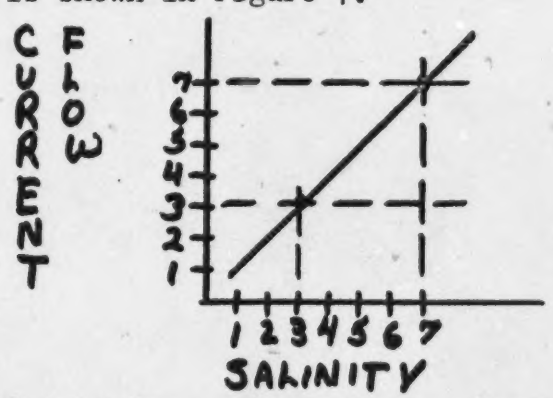


Figure 7, A Salinity vs Current Flow Graph Showing the Placement of Parallel Lines as Part of the Point Determination

The rise is the number of units of rise on the y axis between points A and B. The run is the number of units on the x axis between points A and B.

rise = 7 - 3 = 4; run = 7 - 3 = 4

slope = rise/run = 4/4 = 1

Once the value for the slope has been found, it may be substituted in the formula for m.

$$y = 1x + b$$

The y intercept value can be found by substituting the coordinates of a known point into the formula for x and y; in this case the coordinates of point A.

$x = 3$; $y = 3$

$3 = 3 + b$

$b = 0$

$y = x + 0$

$y = x$

In this case the y intercept is 0, indicating that the line travels through the origin of the coordinate system. The 0 also indicates that when the salinity of the solution is 0 o/oo, the amount of current flow is 0. The formula

$$y = x$$

is the equation for the line in our example and it tells us that for each unit of salinity there is a unit of current flow. Once the equation is known it can be used in future work to determine the salinity directly from the current

reading by simple substitution (while the equation may be somewhat more complicated in other cases, the principles are the same).

SUMMARY

The salinity meter may facilitate learning in many academic areas. Those mentioned here are perhaps only the most obvious. It may be used in chemistry to study the principles of ionization which occur when NaCl is dissolved in H_2O etc. The device may also be used as an aid to discovery learning techniques. More subtle but equally important in the study of science and the scientific process is that the meter may be used as an aid in teaching students to control and manipulate variables and to synthesize new knowledge.

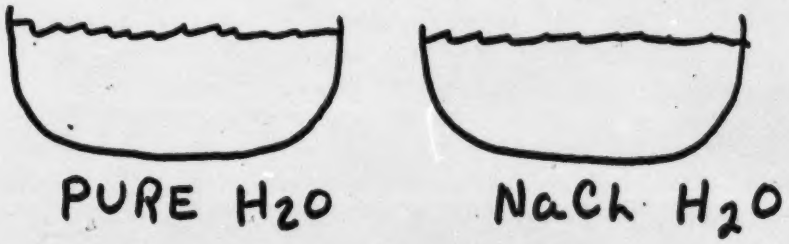
Use of the meter in academic areas other than those related to the marine world (if such a condition really exists) aids in developing marine environmental awareness.

In the final analysis, allowing the student to build his own salinity meter or measuring instrument provides a rich hands on experience. In addition, it provides those without extensive abstract reasoning abilities, a chance for a concrete experience which may lead to intellectual satisfaction and true understanding of the salinity concept rather than just another frustration.

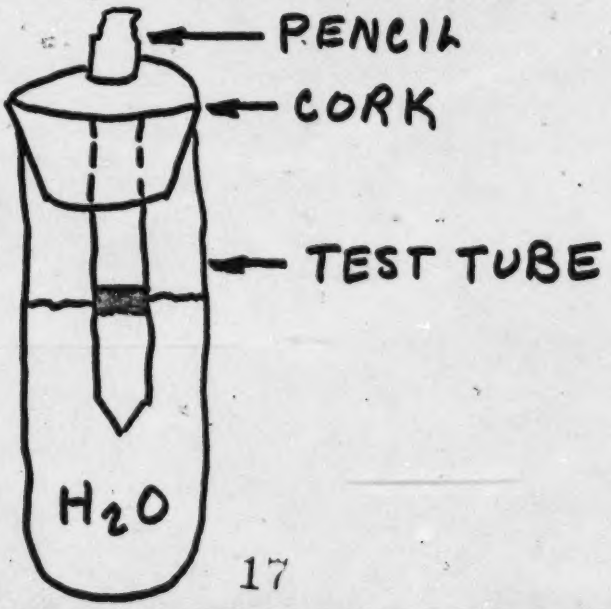
OTHER INEXPENSIVE METHODS OF EVALUATING SALT WATER

The methods which are presented in this section will allow only coarse evaluation of salt water. They are; however, excellent aids to discovery learning.

1. Petri Dishes. The dishes (2) are filled with unknown liquids and then allowed to evaporate. The dry dishes are weighed (the residue from the salt water will cause one dish to weigh more than the other). Students may then taste the residue and hopefully conclude that one of the original solutions was salt water.

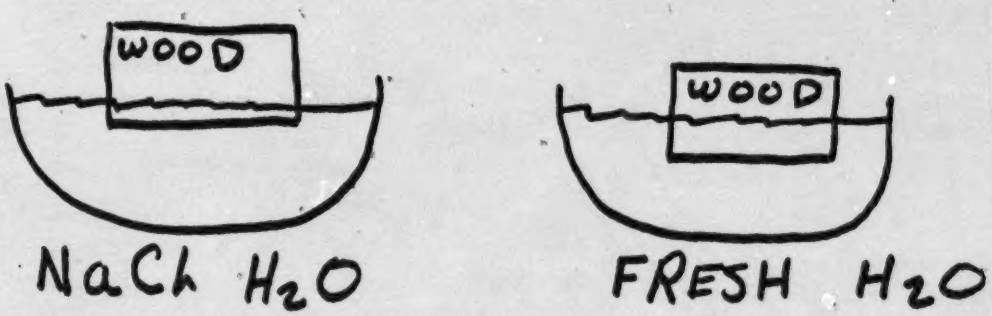


2. Test Tube, Cork, and Pencil. A simple salinity measuring device may be built using these items. Since the



density of seawater is greater than that of fresh water, the level to which the pencil becomes emersed will vary with the salinity of the solution (the greater the salinity, the greater the density and the more buoyant the pencil).

3. Blocks of Wood. A block of wood is floated in two unknown solutions (one is fresh water and the other is salt water). Obviously, the block will be more buoyant in one solution than the other. This exercise can be done twice using blocks of different (e.g. pine and oak) types of wood (this shows the student that the difference in buoyancy between solutions must be due to the solution and not the wood). Students can then taste both solutions and should conclude that there is some difference between the salty solution and the fresh water. Some students may even point out that the salt is the cause of the observed difference.

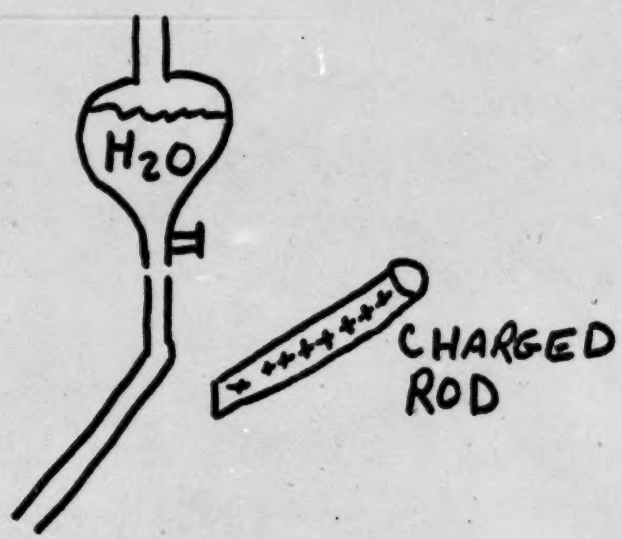


4. Freezing Point Lowering. Students observe the freezing points of two unknown liquids. Once the difference in freezing points are discovered (saline water freezes at a

lower temperature than fresh water) students should be allowed to taste both solutions.

5. Boiling Point Elevation. The same process may be followed here as was followed in #4 except that boiling point rather than freezing point is observed.

6. A Stream of Water and a Charged Rod. A stream of unknown solution is allowed to flow from a burette (use fresh water first). A glass or rubber rod is charged by rubbing with a piece of wool or fur. Once charged, the rod is held close to the stream of water. This procedure is then repeated with the salt water (the salt water will be deflected a greater amount by the charged rod than the fresh water). Students are then allowed to taste both samples.



7. Comparisons of Masses of Solutions. The masses of equal volumes of two unknown solutions may be compared (salt water per unit volume will have a greater mass than a unit volume of fresh water).

mass = density/volume

density of fresh water = 1g/cc

density of salt water = 1.022g/cc

mass of fresh water = 1g/cc x 1cc = 1g

mass of salt water = 1.022g/cc x 1cc = 1.022g

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